

SHORT COMMUNICATION

THE USE OF FRUITS BY THE NEOTROPICAL HARVESTMAN *NEOSADOCUS VARIABILIS* (OPILIONES, LANIATORES, GONYLEPTIDAE)

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Harvestmen are solitary, nocturnal foragers that have a variety of feeding habits, ranging from scavenging to predation (see review in Gnaspini 1996). Although harvestmen seem to be generalist omnivorous arthropods, accepting both plant and animal matter, several species show a tendency to carnivory (Bristowe 1949; Capocasale & Bruno-Trezza 1964; Anuradha & Parthasarathy 1976; Gnaspini 1996; Machado et al. 2000). Reports of frugivory in harvestmen are scarce and in general are restricted to captive animals (Capocasale & Bruno-Trezza 1964; see also Gnaspini 1996). In this paper we provide the first detailed account of frugivory by a harvestman species, and investigate if fruit size and chemical content of the fleshy portion can influence fruit use by the harvestmen.

The study was conducted from October 1995 to February 1997 in the lowland forest of the Parque Estadual Intervalas (24°14'S, 48°04'W), a 490 km² reserve located in the Ribeira Valley, São Paulo state, southeast Brazil. The study site (Saibadela Research Station, elevation 70 m) receives about 4200 mm of rainfall a year, with no month receiving less than 100 mm. Rainfall, however, is less intense and less frequent between April and August, when the temperature may drop to nearly 10 °C (mean \pm SD = 20.8 °C \pm 2.5 for the study period). This period contrasts with the wetter period (September–March) when temperatures may reach 42 °C (25.7 °C \pm 2.8).

The vegetation is predominantly composed of old-growth forest (*sensu* Clark 1996) with an open understory and trees reaching up to 30 m.

The fruits of the following trees were used to investigate frugivory in harvestmen: *Virola oleifera* (Myristicaceae), *Eugenia stictosepala* (Myrtaceae), *Cabranea canjerana* (Meliaceae), *Citharexylum myrianthum* (Verbenaceae), *Alchornea glandulosa* and *Hyeronima alchorneoides* (Euphorbiaceae), throughout this paper referred to only by their generic names. Besides their availability, these fruits were selected for study because (1) they fall within three discrete size classes commonly found in tropical forests (Corlett 1996; see Table 1); (2) all of them are covered by a thin skin which allows the exploitation by harvestmen, and (3) they fit within two distinct extremes relative to the lipid content of their fleshy portions; the arils of *Virola*, *Cabranea* and *Alchornea* are lipid-rich, while the pulps of *Eugenia*, *Citharexylum* and *Hyeronima* are lipid-poor (Table 1). The fruits of *Eugenia*, *Citharexylum* and *Hyeronima* are drupes bearing one (*Eugenia* and *Hyeronima*) or two seeds (*Citharexylum*). The fruits of the remaining species are capsules that open to expose the 1–12 fruits, i.e., seeds coated by red (*Virola* and *Alchornea*) or orange (*Cabranea*) arils. These fruits are eaten by birds, monkeys and/or bats which frequently drop many fruits under the parent plants (Galetti 1996; Pizo

Table 1.—Fruit maturation period, morphology, size class (following Corlett 1996) and chemical composition of the six fruits studied. Morphological values are means \pm SD. At least 20 fruits of each species were weighed. L = lipids, P = protein, TC = total carbohydrate (i.e., soluble + structural carbohydrates). Lipids, proteins and ashes were analyzed according to the methods described in Bligh & Dyer (1959), AAC (1995, method # 46-13) and AOAC (1984, method # 22027), respectively. Total carbohydrates were obtained by difference.

Fruit	Maturation period	Morphology		
		Total weight (g)	Fresh weight of pulp/aryl (g)	Size class
<i>Hyeronima</i>	Mar-Apr	0.05 \pm 0.01	0.03 \pm 0.01	small
<i>Alchornea</i>	Oct-Nov	0.09 \pm 0.01	0.03 \pm 0.01	small
<i>Citharexylum</i>	Feb-Mar	0.9 \pm 0.2	0.7 \pm 0.2	medium
<i>Cabranea</i>	Sep-Dec	0.9 \pm 0.3	0.09 \pm 0.02	medium
<i>Eugenia</i>	Apr-May	5.8 \pm 1.2	2.1 \pm 1.0	large
<i>Virola</i>	Jul-Oct	3.5 \pm 1.2	1.1 \pm 0.5	large

1997). The period of fruit maturation for the six plant species is presented in Table 1.

Voucher specimens of the harvestman were deposited in the Museu de Zoologia da Universidade de São Paulo (MZUSP), and plants at the herbarium of the Universidade Estadual Paulista at Rio Claro (HBRC).

We made diurnal and nocturnal censuses (35 days) of the harvestmen attending fresh fruits placed on the forest floor along a transect established 1–2 m off one of the trails that crossed the study site. One hundred fruits of *Virola* and 50 fruits of the other five species were set along the transect 5 m apart. Each fruit was protected from vertebrate removal by wire cages (15 \times 15 \times 10 cm, 1.5 cm mesh) closed on the top and staked to the ground. Plastic wraps placed on the top of cages protected fruits and harvestmen from being disturbed by light to moderate rains. No census was conducted under heavy rains for which the plastic shelters were useless. Fruits were set on the transect at 0800 h and checked at four-hour intervals throughout a 24 hour period. The daily light period at the study site span from 0600–1800 h, thus rendering two diurnal and two nocturnal censuses.

Only one harvestman species, *Neosadocus variabilis* (Mello-Leitão 1935), was recorded on the fruits. Individuals of *N. variabilis* were observed exploiting fruits of *Cabranea*, *Alchornea*, *Eugenia*, and *Virola* (Table 1). No harvestman was seen consuming fruits of *Citharexylum* and *Hyeronima*. Large fruits as a whole were more exploited than smaller ones ($\chi^2 = 10.94$, $df = 1$, $P < 0.001$; medium

and small fruits combined). Although there is a tendency for the harvestmen to exploit lipid-rich fruits as compared to lipid-poor ones (5.5% vs. 2.0%, respectively), the difference did not reach statistical significance ($\chi^2 = 2.73$, $df = 1$, $P = 0.09$). *Neosadocus variabilis* seems to be a strictly nocturnal forager since it was recorded only during the night censuses, i.e., from 2000–0400 h. Individuals fed on the pulp or aril of the fruit on the spot, never displacing them.

Although Walker (1928) stated that harvestman diet can consist of fruit juices and other plant-derived matter, few studies have documented fruit use by species of the order. Edgar (1971) observed the palpatoid *Leiobunum vittatum* (Say 1821) feeding on a ripe wild raspberry and, among the Laniatores, *Acanthopachylus aculeatus* (Kirby 1819) accepts papaya in the laboratory (Capocasale & Bruno-Trezza 1964), while *Neosadocus variabilis* was seen eating fallen fruits in the field (Gnaspini 1996; this study). Despite the scarcity of records, the exploitation of fallen fruits by ground-dwelling harvestmen is possibly more common than previously thought, especially for those species inhabiting tropical rainforest where a great amount of fleshy fruits is produced on a year-round basis (Jordan 1993). At our study site, for example, more than 500 kg/ha/year of fleshy fruits reach the forest floor (Pizo unpubl. data) almost continuously through the year (Morellato et al. 1999).

Results regarding the choice of fruits by *N. variabilis* based on their size and lipid content

Table 1.—Extended.

Percent of water	Chemical composition (percent of dry mass)			% of harvestmen visiting
	L	P	TC	
85.6	7.9	6.3	—	0
43.3	68.4	7.6	21.7	2
81.4	6.3	6.8	82.7	0
47.7	70.8	10.3	16.5	2
77.9	5.2	8.5	85.5	6
62.7	61.8	4.6	32.1	9

must be interpreted cautiously since small fruits are rapidly removed by ants (Pizo & Oliveira 2000), thus becoming unavailable for harvestmen. In any case, large fruits may represent more attractive food sources because they bear a great amount of fleshy material, either pulp or aril (Table 1). The use of lipid-rich fruits by harvestmen, on the other hand, deserves further investigation. In our study, *N. variabilis* exploited all the three lipid-rich fruits tested, and only the largest lipid-poor fruit. The fruits tested also differ in their carbohydrate content. This is expected since lipids and carbohydrates are highly negatively correlated in our fruit sample (Spearman rank correlation: $r_s = -0.90$, $n = 3$, $P = 0.03$), as usually occurs for fleshy fruits in general (Jordanano 1993; Pizo & Oliveira 2000). There is no *a priori* reason to suspect that harvestmen would avoid carbohydrate-rich fruits. The emphasis on the role of the lipid content of the fruits in their use by harvestmen, on the contrary, is justified because it has been shown that lipid-rich fruits serve as food for carnivorous arthropods such as ponerine ants (Horvitz & Beattie 1980; Pizo & Oliveira 1998, 2000), and also attract other non-frugivorous arthropods, e.g., cockroaches and grasshoppers (Pizo unpubl. data). Carroll & Janzen (1973) hypothesized that, from the ants' viewpoint, the lipid-rich fruits may be chemically analogous to their insect prey, an idea supported by the comparison made by Hughes et al. (1994) between the fatty acid composition of elaiosomes, lipid-rich food bodies of typical myrmecochorous fruits, and insects. Given that elaiosomes and the arils of lipid-rich fruits are chemically and morphologically similar structures (Hughes et al. 1993), it is possible that harvestmen use these fruits more often than we have previously suspected.

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